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CONCEPT PROPOSAL FOR AN AN/PVS-5 SIMULATOR

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An AN/PVS-5 simulator has been designed at USAARL to supplement night vision goggle (NVG) training for ground units. This report discusses the specifications, characteristics, applications, benefits, and costs of the AN/PVS-5 simulator prototype.

The AN/PVS-5 simulator is a low-cost item consisting of the standard faceplate (without electrical components) and cushion with a sheet metal and filter insert that does not use batteries, which are the highest life cycle costs for NVG operations. The NVG is simple and easy to use, and durable with little or no maintenance requirements. It is designed for daytime training - indoors or outside as long as the ambient light is at a photopic level. The device effectively simulates most NVG conditions to include a 40 degree field-of-view, reduced acuity, loss of peripheral vision, loss of color cues, added out-of-balance weight, closed-in feeling around the face, etc. The AN/PVS-5 simulator is employable in most operational and environmental situations and is at least as safe to train with as actual NVGs.

Fielding an NVG training simulator would reduce wear and tear, and increase the longevity of actual NVGs. Supplementing training with the simulator would offer substantial cost savings by reducing the consumption of batteries used to power the actual NVGs. The NVG simulator has additional pragmatic advantages over actual NVGs by its durability and widespread mission or training applications. The AN/PVS-5 simulator would supplement training equipment needs for units receiving fewer NVGs than their basis of issue due to procurement and budgetary restrictions.

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Concept

To provide a low-cost, low-maintenance, realistic simulator to be used in training with the standard AN/PVS-5 night vision goggles (NVG).

Statement of need

AirLand Battle doctrine places an emphasis on night training for all combat and combat support units. Future combat operations will stress exploiting all tactical environments, 24 hours a day. This will lead to an increased emphasis on night training with night vision devices Armywide.

While night vision devices such as night vision goggles (NVG) have been fielded in the Army for years, only the aviation component has well-established, specific qualification and currency requirements for NVG training and operations. Aside from aviation, NVGs have been authorized for infantry, armor, military police, logisticians, medics, maintenance, and many other ground units and personnel. Some ground units such as the 9th Infantry Division and many units in Europe already have been training with NVGs for an extended period. However, many authorized units do not have enough NVGs with which to train. Some units that have NVGs are reluctant to train with them for fear of loss or damage, are unfamiliar with their use, and avoid training in the absence of established skill qualification training (SQT) requirements or an Army Test and Evaluation Program (ARTEP). Currently, this is being remedied by revisions in unit TOEs, continued NVG procurement, and the writing and establishment of guidelines, SQT requirements, and ARTEPs for all units as they gain NVG capability.

Unfortunately, as the requirement for NVG training and capability increases Armywide, the costs increase. These costs include initial procurement, maintenance, battery supply, repair, and replacement. For ongoing training, the cost of batteries alone, necessary to power the NVGs, is substantial. In fact, the driving cost factor in the life cycle of NVGs is batteries. To help defray life cycle costs, the Army could benefit greatly by employing a realistic simulator to supplement NVG training.

An NVG simulator should have most or all of the following properties:

1. Low cost.
2. Durable with little or no maintenance requirements.
3. Simple and easy to operate.

4. Effective simulation of most NVG features (for example: field-of-view, added out-of-balance weight, reduced acuity, loss of peripheral vision, loss of color cues, closed-in feeling around the face, etc.).
5. Employable in most operational and environmental situations.
6. At least as safe to train with as actual NVGs.
7. Well-suited for training during daylight duty hours.
8. Usable in qualification training or in meeting training requirements.
9. Similar parts (if employed) could be available as spares for actual NVGs.

The following description is a concept proposal for an AN/PVS-5 simulator that meets all nine of the listed criteria for effective simulation of the daylight training NVG environment.

Description of simulator

A draft drawing and a series of photographs of the prototype are shown at the end of this report. The proposed NVG simulator consists of an insert which is placed inside a standard AN/PVS-5 faceplate. The insert is made of 22-gauge sheet metal, constructed from three pieces, joined by soldering or spot welds. Each viewing port is punched out and drum sanded. A soft plastic hose is split and glued to the septum with epoxy to protect the nose from the edge of the sheet metal.

Constructed to the general dimensions given in Figure 1, the insert fits snugly into the standard AN/PVS-5 faceplate without light leaks or glare problems. Painting the insert a flat black further reduces the glare during daytime viewing. Since the insert is snugly fit, it still can slide in and out, allowing adjustment of the septum close enough to the nose to prevent viewing from either eye through the opposite hole of the insert.

The septum and lambskin face cushion can be modified to allow a soldier to wear spectacles when using the simulator. A simple modification to only the face cushion as shown in Figure 10 allows a soldier to wear spectacles with the aviator-style frames (Bayonet Temple, NSN 6590-01-099-2321). With additional modification of the faceplate, cushion, and insert as shown in Figures 11-13, the standard black, plastic spectacles (S-10 Eyeshape, NSN 6540-00-482-0000 [remaining four-digit number refers to sizes]) can be worn when using the simulator. Even the new brown frame spectacle (6540-01-147-4670) is suitable.

The length of the insert is designed specifically to reach the lambskin face cushion on the inside of the goggles as the lip on the front of the insert abuts the front of the faceplate. This puts all of the pressure against the faceplate cushion in case of accidental impact while the simulator is worn.

The front of the insert is made at a slight angle so viewing through the insert appears more comfortable; that is, about perpendicular to the normal optical axis. As long as the wearer has an average-sized nose and interpupillary distance (from 60-68 mm), adjusting the insert as close as possible to the face will yield either an individual eye or combined stereoscopic field-of-view comparable to NVG viewing, or about 40 degrees. The farther the viewing ports from the insert, the smaller the field-of-view. Conversely, shortening the insert could yield a wider field-of-view. Thus, one size will work for all users.

The weight of the prototype insert is 9.7 ounces; the stripped down faceplate without the electrical components weighs 4.3 ounces for a total of 14 ounces. This is less than the standard AN/PVS-5 (1.9 pounds), but thin lead or heavy metal strips could be attached securely inside the lateral sides of the insert or on top of the faceplate to equal the actual NVG weight.

To better simulate NVG viewing, a green color filter made of polycarbonate is attached to the outside of the viewing port plate. The filter material used in the prototype is a 3-mm thick, blue-green polycarbonate filter with a peak transmittance between 470 nm and 550 nm. This filter passes a dominant wavelength approximately equal to the phosphor emittance of actual NVGs.

While the blue-green filter allows nearly 20/20 acuity, this can be reduced to NVG-comparable acuity (about 20/50) by adding a sheer mesh screen such as a woman's nylon stocking. In fact, green ultrasheer nylon stockings were used in the prototypes. The blue-green color filter and green nylon stocking work well in simulating the actual NVG phosphorescent image for its color, acuity, stippled image, and loss of color cues.

The nylon stocking in the prototypes is sandwiched between a 1.8 mm clear plexiglass shield and the 3 mm blue-green filter. The filter system is bolted to the front of the simulator insert, rough sanded around the edges, and sealed with a silicone epoxy to further protect the nylon mesh screen.

During daytime use there is a small region of visibility down around the nose when the simulator is worn. Most of this can be eliminated by a small flap of duct tape or leather

material being attached along the bottom inside curvature of the standard faceplate. However, our experience with the simulator has convinced us that this is not necessary because the area is well below the normal field-of-view. Figure 14 shows a prototype with a leather flap attached to the bottom of the faceplate to prevent light interference.

Cost

Approximate costs to produce the simulator prototypes are given in the following cost summary. Cost figures are based on the average cost per unit for 22 production prototypes. For easy comparison, a cost summary for the AN/PVS-5 also is given here.

AN/PVS-5 simulator (prototypes)

Faceplate without electrical components	$ 10.00
Lambskin face cushion (GSA price)	21.53
Polycarbonate blue-green filters	50.00
Fabrication of insert	50.00
Approximate cost per prototype:	$ 132

For a larger order, industry sources indicated that polycarbonate filters would cost well below $50 each. In mass production, the NVG simulator should cost less than the cost of producing each prototype. There is no reason the insert could not be produced out of a hard, durable plastic or polycarbonate. The removable blue-green color filter easily could be produced or procured with the proper dominant wavelength, luminous transmittance, and opacity to yield equivalent NVG characteristics. Compared to the cost of an actual AN/PVS-5, the simulator is a genuine bargain.

AN/PVS-5 NVGs

Complete system--originally $5,000/set, now $4,500/set

Replacement tubes--$1,530/tube
Replacement objective lens--$333/set
Replacement faceplate with electrical components--$141
Replacement lambskin face cushion--$21.53
Batteries--mercury: $3.83 each; lithium: $5 each
New battery packs will allow the use of 2 AA alkaline batteries at a cost of 60 cents each

Maintenance and test equipment costs are included in initial purchase of NVGs.

Usefulness as a learning aid

The proposed NVG simulator especially would be useful in initial qualification training as a close approximation to an actual night vision goggle, but also would be a useful adjunct for SQT, ARTEP, or premission daytime training because of the effective simulation of actual NVGs that it offers. Five different adjustments have to be accomplished for a soldier to become and remain proficient in NVG operations.

1. The soldier must adapt to the limited, 40 degree field-of-view and loss of peripheral vision. This further requires developing better scanning techniques by making more head and body movements, but not too rapidly.

2. The soldier must get used to the closed and uncomfortable feeling experienced when having the NVG faceplate pressing against the face.

3. The soldier must become adapted to the added, out-of-balance weight inherent in NVG operations, sometimes for extended periods of time (2 hours or more).

4. It also is well established that NVG operations are much more stressful and fatiguing than most other operational environments (FC 90-1). Even with a lot of training and experience, NVG operations still cause significant stress and fatigue. Adjustment to these factors only can be made with experience in NVG operations.

5. Finally, a soldier must become well acquainted with NVGs as an optical device. This involves learning to make diopter and focal length adjustments, setting interpupillary distance, and interpreting phosphorescent images of limited acuity compared to normal, accommodated vision, without the benefit of color vision.

The advantages of this simulator are simplicity of design, durability, low cost, and effective simulation of most learning/adaptation parameters inherent in NVG operations. The proposed NVG simulator would be useful in simulating the following adjustment parameters:

1. The device has a comparable field-of-view, eliminates peripheral vision, and requires similar scanning techniques when compared to the standard AN/PVS-5 NVG.

2. Since the same faceplate is used in the simulator and AN/PVS-5 NVGs, adapting to the closed-in feeling and pressure against the face would be identical.

3. Since the simulator could be made to weigh as much as the standard AN/PVS-5 NVG, adjusting to the out-of-balance condition and added weight to the head also would be identical.

4. The NVG simulator offers several advantages to training over the exclusive use of NVGs in night operations. Use of the NVG simulator in the daytime environment would be less stressful and fatiguing than the use of AN/PVS-5 NVGs in actual night operations primarily because there would be no disturbance of a soldier's normal, light-dark biological cycle. By "successive approximations," an established, effective learning technique, soldiers will transition more easily and safely into NVG operations. Experience and familiarity with the simulator also would help reduce some of the stress and fatigue that occurs when actual NVG training is conducted.

5. The system does not contain any electro-optical components such as lenses, a photomultiplier, or phosphorescent screen. Were it to do so, however, the system would cost a lot more money, thereby nullifying one of its principal advantages.

Training and currency applications

The NVG simulator is best suited for a daytime training environment--indoors or outside as long as the ambient light is at a photopic level. Although not recommended, the device could be used at night for unaided conditions, but the blue-green filter and mesh screen would have to be removed.

Currently, NVGs have been authorized for all combat units, and most combat support and combat service support units. Aviators currently use a modified AN/PVS-5 NVG that allows look-under capability and some peripheral vision. The modified AN/PVS-5 will be used by aviators until replaced by the AN/AVS-6 (ANVIS). Unfortunately, the NVG simulator is not suitable as a training aid for the aviator using the modified AN/PVS-5 or ANVIS; however, other aircrew members will continue to use the AN/PVS-5 with the full faceplate.

Presently, some 36,000 NVGs are in use by the Army, with 71,000 more anticipated to be in the field by the second quarter FY 87. But, that number still falls far short of the number needed to train all the troops authorized and expected to become qualified in NVG operations. The requested basis of issue is for

140,000 NVGs. TOE units with limited numbers of NVGs especially could benefit from this NVG simulator to help meet training requirements.

We recommend having a specified number of days and times that trainees would be required to wear the simulator. For qualification training, a soldier could be required to wear the simulator for up to 5 training days, starting at 2 hours and increasing to 4 hours each day. For currency, a qualified soldier could be required to use the simulator during routine training for at least 10 hours every 6 months at no less than 2 hours per wearing. Using the NVG simulator would not necessarily add additional time to any current training syllabus.

A soldier can perform safely almost any type of job or training activity while wearing the NVG simulator, be it driving a truck or low-crawling under barbed wire. In fact, because of the device's durability, it could be used in any weather conditions or in a dust-filled environment where commanders may be very reluctant to conduct training with the actual NVGs.

A daylight training simulator would be useful especially in far northern latitudes when there are long seasons with little or no dark periods. The simulator also would be a practical solution to units with limited or restricted opportunities or facilities for actual night training, e.g., National Guard and Reserve units. Finally, there would be additional cost savings by being able to supplement training during normal duty hours when night facilities, ranges, and extra required personnel would be more costly.

The AN/PVS-5 is anticipated to remain in the inventory until at least 1995. This would make the NVG simulator useful for years to come. However, even with the addition of other generic NVGs and possibly a single objective tube AN/PVS-7 NVG, this NVG simulator would be useful for these models as well. Even the AN/PVS-7 with a single objective tube still will have two viewing tubes with about 40 degree fields-of-view.

Logistical considerations

Fortunately, there would be little or no maintenance to worry about with the NVG simulator. The same supply personnel who issue and maintain NVGs would handle the simulators. The faceplate with the electrical components requires no configural changes to accommodate the training insert, leaving it readily available as a spare part when needed for the standard AN/PVS-5 model.

Advantages and benefits

Currently, there is no such training aid in the Army or elsewhere. The tangible advantages and benefits of adopting the proposed simulator are:

1. Transition into NVG operations would be simpler and safer.
2. Supplementing training requirements by replacing the expensive NVG in certain training environments would reduce wear and tear, thereby increasing the longevity of actual NVGs.
3. Supplementing training with the NVG simulator would offer additional cost savings by substantially reducing the consumption of batteries used to power the actual NVGs.
4. It would provide additional pragmatic advantages over NVGs by its durability and widespread mission applications. As now configured, only NBC ground missions and aviation missions would be excluded.
5. It has all-weather and all-terrain capabilities.
6. The AN/PVS-5 simulator would supplement training equipment needs for units receiving fewer NVGs than their basis of issue due to procurement and budgetary restrictions.

Daylight filters and NVGs

Without getting into too much detail, training with this simulator in the daytime environment would be far superior to using actual NVGs with any type of daylight filters. Drawbacks to daylight filter use are possible tube damage from daylight exposure, lens fogging, reverse imaging of bright objects, and greatly reduced contrast and resolution. Currently, shared apertures (lens covers with a small hole in the center) are not authorized for daytime training for the reasons already mentioned, and because daytime use more rapidly degrades the image intensification capability of the system.

Army aviation uses special purpose filters for daylight NVG training, but only 3,900 sets were purchased at $257 per set. These filters have all the drawbacks already described, add significant weight to the front of the NVGs, and cost much more than would the NVG simulator. It's unfortunate that the AN/PVS-5 simulator as configured in this proposal does not satisfy the requirement for aviator NVGs to have a look-under capability, as does the modified faceplate AN/PVS-5 and ANVIS.

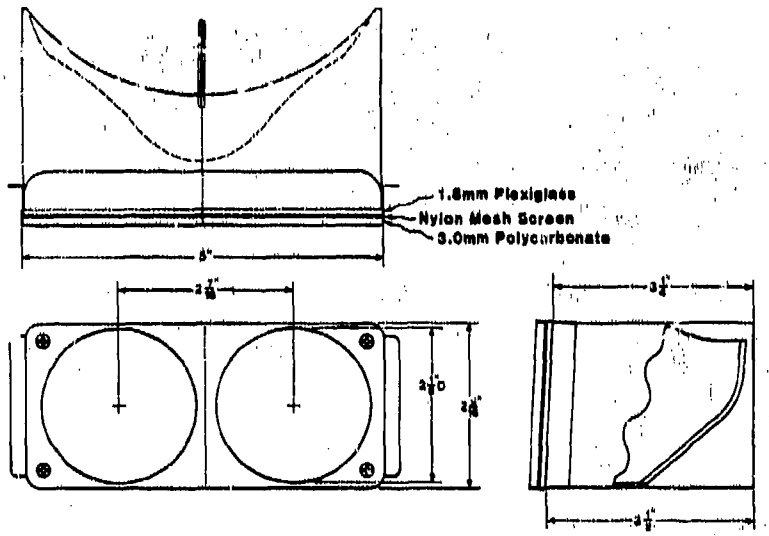

Figure 1. Schematic drawing of the AN/PVS-5 simulator insert.

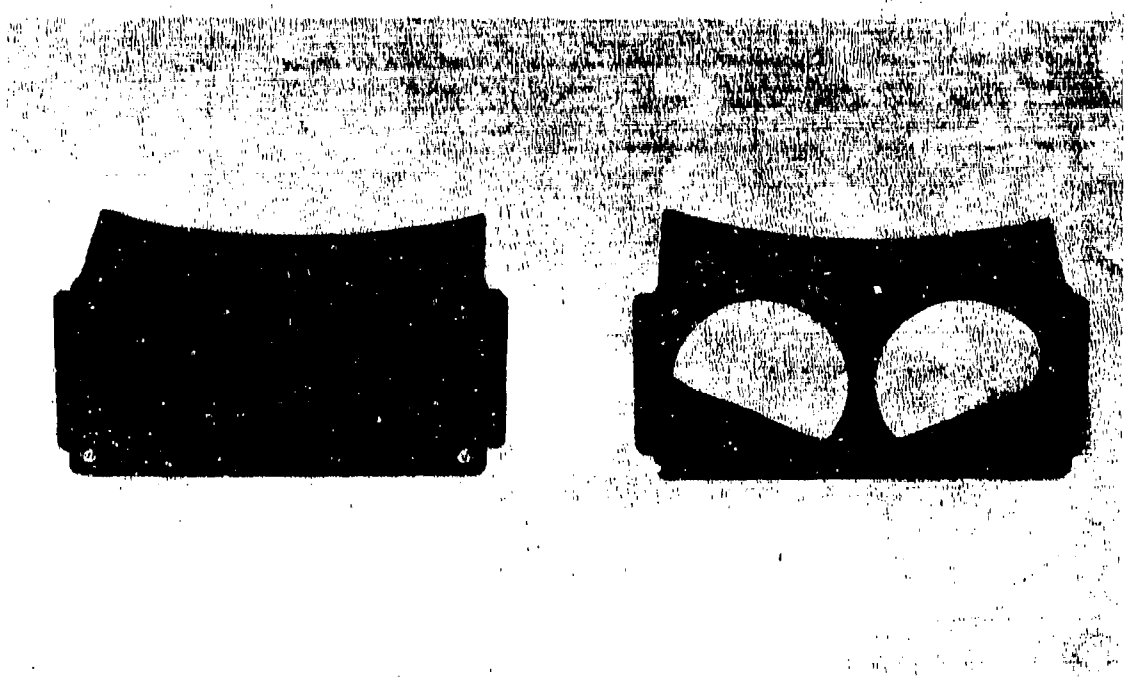

Figure 2. Frontal view of AN/PVS-5 inserts with and without blue-green filter.

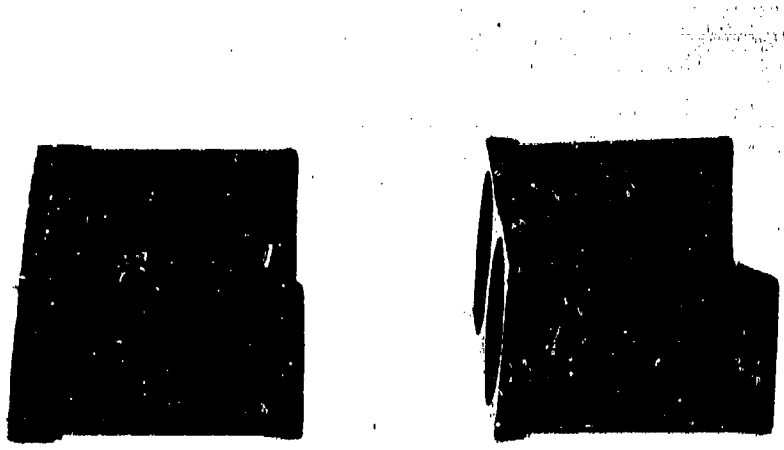

Figure 3. Side view of AN/PVS-5 inserts with and without blue-green filter.

Figure 4. Rear view of AN/PVS-5 inserts with and without blue-green filter.

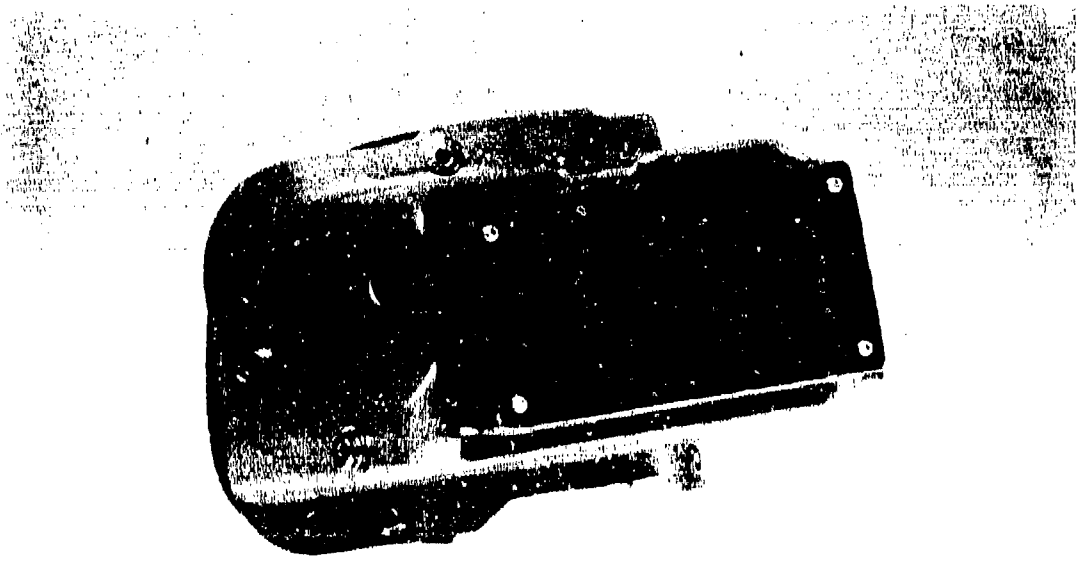

Figure 5. Transverse frontal view of AN/PVS-5 simulator.

Figure 6. Rear view of AN/PVS-5 simulator.

Figure 7. Transverse rear view of AN/PVS-5 simulator.

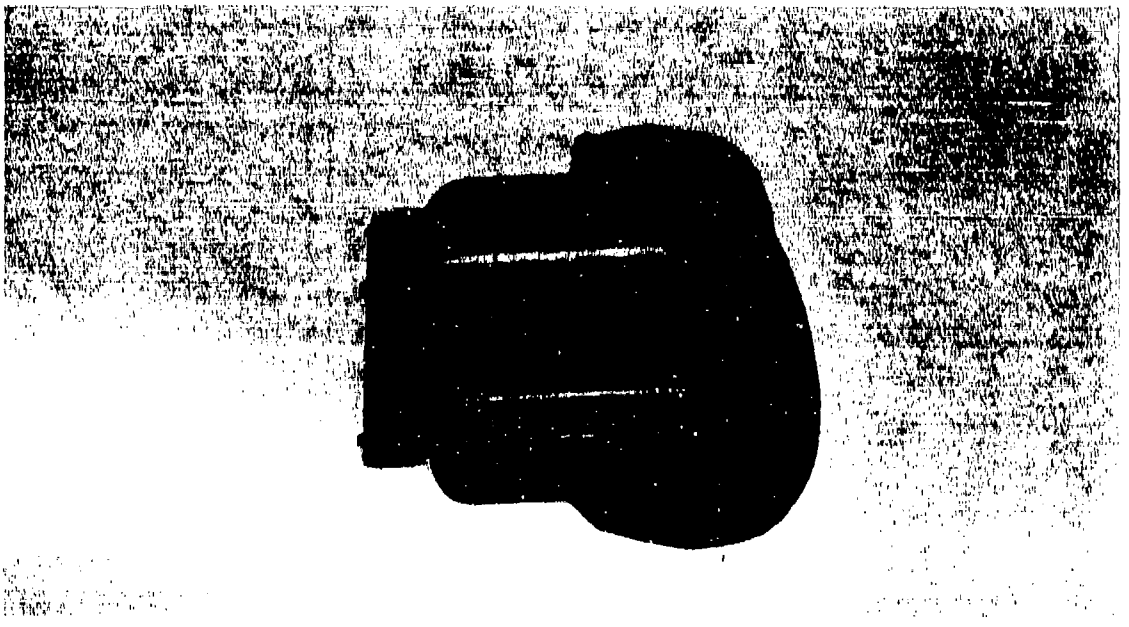

Figure 8. Side view of AN/PVS-5 simulator.

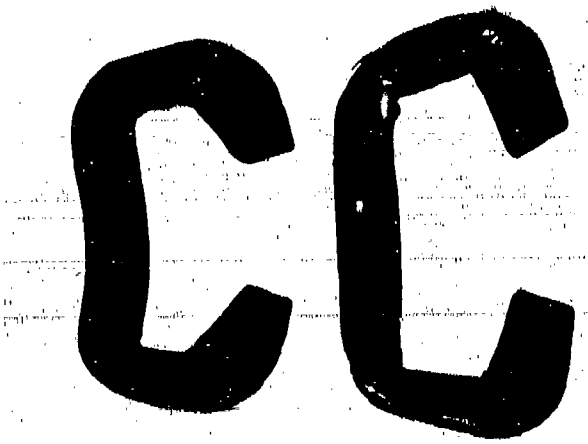

Figure 9. Lambskin face cushions with and without spectacle modification. The face cushion is modified by cutting the lambskin into two cross sections on each side 1 3/4 to 2 inches apart and along the lower inside edge. The padding inside is removed and the button snap underneath cut out. The lambskin flap then is secured back down with duct tape.

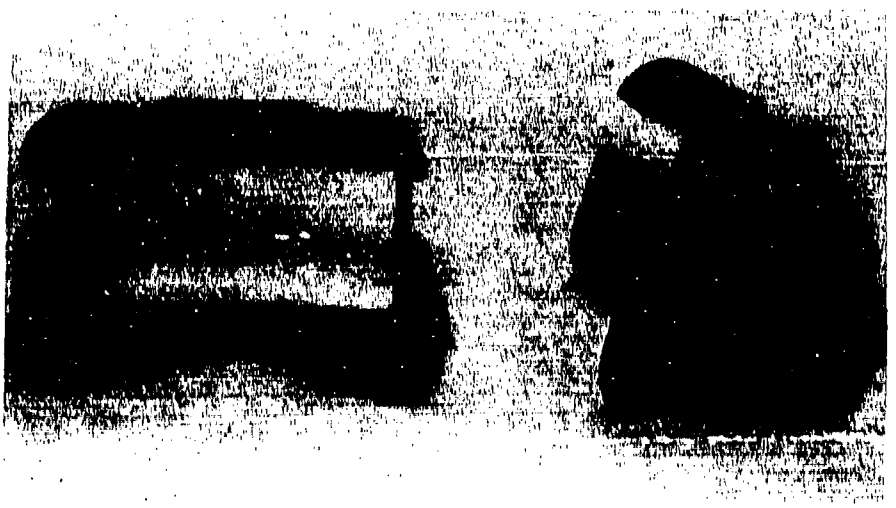

Figure 10. Rear and side views of faceplates modified for spectacle use. The faceplate is modified by cutting out an area about 3/4 to 1 inch high by 1 1/4 inch wide just above the side snaps for the head strap. The modified face cushion should be reattached and the cutout area covered with duct tape to prevent light leaks.

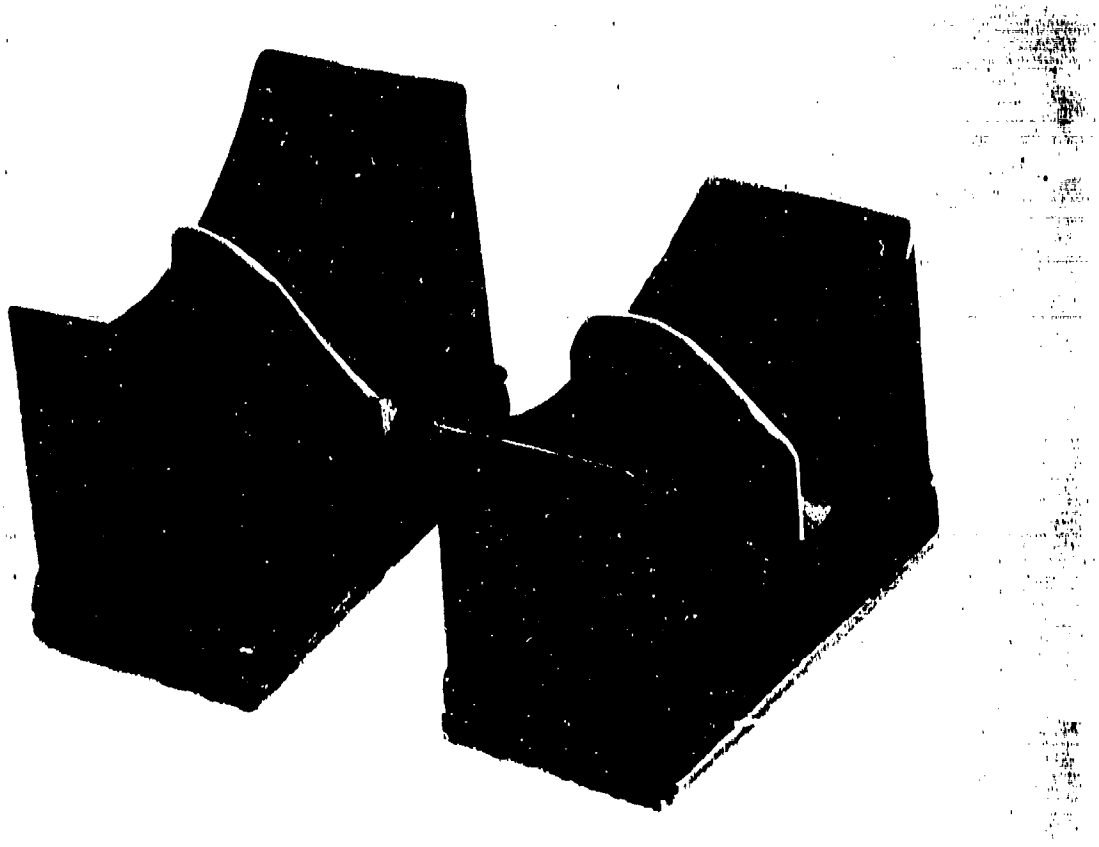

Figure 11. Side view of AN/PVS-5 simulator inserts with and without the septum modification to allow spectacle use. The simulator insert is modified by gradually reducing the taper on the upper half of the septum so that it is about 1/4 to 3/8 of an inch shorter to allow room for the spectacle frame bridge. The lateral sides of the insert also must be cut shorter by about 3/8 inch to allow for the edge of the spectacle frame. Simulator for spectacle use shown on right.

Figure 12. Rear and side views of the AN/PVS-5 simulator with leather flap attached to the bottom edge of the faceplate. The leather edge has been highlighted for photographic contrast.

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